

A Bioluminescence Bathyphotometer for an Autonomous Underwater Vehicle

James F. Case

Department of Ecology, Evolution and Marine Biology

University of California, Santa Barbara

Santa Barbara, CA 93106

phone: (805)-893-2913 fax: (805)-893-8062 e-mail: case@lifesci.ucsb.edu

Award Number: N00014-98-1-0202

<http://lifesci.ucsb.edu/~biolum>

LONG-TERM GOALS

We seek to develop bioluminescence bathyphotometers (BPs) suitable for use on autonomous underwater vehicles, coastal zone moorings and for deployment from small boats operating near shore in order to provide spatial scale data important to understanding plankton population dynamics in the coastal regime.

OBJECTIVES

Building on the experience of this past year in which our new type small BPs (MDDBP) successfully operated in several configurations, we continued to refine them, looking towards establishing a standard unit suitable for general use for oceanographic studies. We also continued sea tests to fully evaluate this equipment.

APPROACH

Two field studies were conducted: December in Monterey Bay and July at the LEO-15 site. Monterey Bay emphasized investigation of capture efficiency of the small BPs while at LEO-15 a major component of the work was a field intercalibration of the small BPs with a HIDEK. The remainder of the year was devoted to laboratory calibrations and data analysis.

WORK COMPLETED

A patent disclosure was made to the University of California covering the basic bathyphotometer. This was subsequently released to the Office of Naval Research.

Two units were provided to the Naval Oceanographic Office for field-testing.

RESULTS

A major question in evaluation of any small BP is its **capture efficiency**. Bioluminescence is produced by an immense variety of organisms, some of which are quite powerful swimmers with excellent sensory endowment. Our MDDBPs are intended only to capture radiolaria, dinoflagellates, copepods, appendicularians and other small protochordates, and small ctenophores and medusae. These represent by far the dominant element of marine bioluminescent sources. Bacterial luminescence

Report Documentation Page			Form Approved OMB No. 0704-0188		
Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.					
1. REPORT DATE 30 SEP 2002		2. REPORT TYPE		3. DATES COVERED 00-00-2002 to 00-00-2002	
4. TITLE AND SUBTITLE A Bioluminescence Bathyphotometer for an Autonomous Underwater Vehicle				5a. CONTRACT NUMBER	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S)				5d. PROJECT NUMBER	
				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Department of Ecology, Evolution and Marine Biology,,University of California, Santa Barbara,,Santa Barbara,,CA, 93106				8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)				10. SPONSOR/MONITOR'S ACRONYM(S)	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release; distribution unlimited					
13. SUPPLEMENTARY NOTES					
14. ABSTRACT We seek to develop bioluminescence bathyphotometers (BPs) suitable for use on autonomous underwater vehicles, coastal zone moorings and for deployment from small boats operating near shore in order to provide spatial scale data important to understanding plankton population dynamics in the coastal regime.					
15. SUBJECT TERMS					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT Same as Report (SAR)	18. NUMBER OF PAGES 4	19a. NAME OF RESPONSIBLE PERSON
a. REPORT unclassified	b. ABSTRACT unclassified	c. THIS PAGE unclassified			

is widespread in the sea but the light is emitted continuously and usually of very low intensity and rarely if ever figures significantly in the bioluminescent light budget of the coastal zone. In both field studies this year capture efficiency was evaluated by fitting the MDDDBPs with nets to capture organisms from the BP's exhaust. The numbers and kinds of these were compared with organisms caught in an immediately adjacent Shindler trap, which provides an excellent representation of organisms present. Organisms collected by both methods were sorted into motile and non or poorly motile categories. For Monterey, the MDDDBPs and Shindler trap data were not significantly different, indicating that the MDDDBP effectively samples the candidate population. The LEO-15 collections are being evaluated.

Another test of capture efficiency was conducted at Monterey in which an MDDDBP was run on an ROV also equipped with a "splat screen" (Widder). The splat screen permits classification of many organisms by their characteristic luminescence when they are hit by the advancing screen. The diameter of the screen is so large that it seems likely that it samples impartially. This data comparison remains to be completed.

The two MDDDBPs provided to the Naval Oceanographic Office were operated attached to a HIDEEX on a typical survey cruise. They have just been returned and we are looking forward to receiving the data when it is available. During LEO-15 an additional small amount of comparative data was obtained by near simultaneous profiling of an MDDDBP and a HIDEEX. An understanding of how the MDDDBPs perform in comparison to HIDEEX is deemed critical since it is the criterion bioluminescence instrument for NAVO.

Lab tests were conducted with guidance from Dr. J. Yen regarding copepod escape dynamics. In addition, flow patterns around inlet and exhaust ports of the MDDDBP were videotaped. Motion of neutrally buoyant particles visualized in laser-defined planes was analysed with motion analysis software. We have discussed this work with Dr. P. Lenz and D. Hartline, experts in copepod escape behavior. The tentative conclusion is that while many copepods respond quickly and precisely enough to dodge a well defined disturbance under laboratory conditions, such as in our experiments, in nature the turbulence field around an instrument in profiling mode is likely to be so chaotic that an escaping organism is probably will not have a directional frame of reference accurate enough to produce an accurately directed escape response.

IMPACT/APPLICATIONS

Investigation of marine bioluminescence is hindered by lack of availability of an instrument such as has been developed in this project. We hope that its characteristics will make it useful as a general oceanographic instrument and thus greatly increase the frequency with which bioluminescence measurements are made at sea in the course of general investigations in biological oceanography.

TRANSITIONS

It is anticipated that the MDDDBP deployed in July 2000, on the LEO-15 optical node will continue indefinitely in use and be maintained by the UCSB/CalPoly Group. It was refurbished last winter and redeployed in June.

We anticipate placing MDDDBPs on moorings already instrumented in the Santa Barbara Channel to study and track the progression of bioluminescent blooms in this region. Through collaboration with

other researchers at UCSB, we will have access to rain runoff data, surface current velocities, ocean color images from satellites, and other physical data. We hope to be able to provide MDDBP's eventually to existing and anticipated moorings between the San Diego and Monterey Bay (Case, Moline, Haddock, Latz)

PUBLICATIONS

Case, JF et al (2001) Proceeding of the 11th International Symposium on Bioluminescence and Chemiluminescence. xx+517 pp. World Scientific Publishers, Singapore

Moline, MM, EK Heine, JF Case, CM Herren and O Schofield (2001) Spatial and temporal variability of bioluminescence potential in coastal regions. Proc. 11th Int. Symp. Biolum. Chemilum., pp 123-126

Herren, CM, JF Case, DV Holliday, C. Greenlaw, D McGehee, D Lapota (2001) Fine-scale coastal bioluminescence using newly developed small bathyphotometers. ASLO Proceedings, Albuquerque, NM